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## SHUTTER ASSEMBLY FOR A LUMINAIRE

### Field of the Invention

[0001] The present invention relates to a shutter assembly, and more particularly to an improved framing shutter assembly for a luminaire.

### Description of the Prior Art

[0002] Theatrical luminaires can be provided with shutters to provide a projected, framed light beam of a selected shape and size. In typical arrangements, four shutter blades are mounted within the luminaire housing for movement relative to the light path. The blades can be translated radially into and out of the light path and each can be rotated in the peripheral direction around of the light beam. By arranging the shutter blades, the projected light beam can be square or rectangular or have other straight sided shapes such as triangular or trapezoidal, and the projected shape can be oriented at a selected rotational position.

[0003] In the past, manually operated shutters were common. In a manually operated shutter assembly, handles projecting from the sides of the luminaire are manipulated to place the shutter blades in the desired positions. Because of the inconvenience of manual adjustment for each modification in the light beam shape, a need has arisen for a motor operated, automated, remotely controlled shutter assembly.

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[0004] Existing automated shutter assemblies are subject to disadvantages. Typically, known arrangements are very complex, requiring many intricate parts and assembly operations and resulting in high material and assembly labor costs, large size and poor reliability. Large size is a problem because it may require a large luminaire housing to contain the shutter assembly and because it may make it difficult to locate all of the shutter blades at or very close to the desired optical point such as at a focus point along the light path. In many designs the motors used for operating the shutters have been mounted for movement in the assembly and have been drivingly connected to the shutters by complicated and expensive mechanisms. A disadvantage of movably mounted motors is the need to route electrical cabling to the moving motors. There is a long standing need for a simple, inexpensive, reliable and compact framing shutter assembly for a luminaire.

[0005] U.S. patent 6,550,939 discloses a shutter apparatus of a complex design that is expensive to make and assemble. It has a number of individual shutter assemblies, each including a shutter blade that is moved by a system of shutter blade drive motors and linear driving members. In addition, a further motor is used to rotate the entire shutter system including the shutter blade drive motors and linear driving members.

### **Summary of the Invention**

[0006] A primary object of the present invention is to provide an improved shutter assembly for a luminaire. More specific objects of the invention are to provide a framing shutter assembly that is very simple, easy and inexpensive to fabricate and assemble, reliable, and compact, thereby overcoming disadvantages of known shutter assemblies and fulfilling the long standing need for a simple, reliable and compact framing shutter assembly for a luminaire.

[0007] In brief, in accordance with the invention there is provided a framing shutter assembly for a luminaire providing a beam of light. The framing shutter assembly includes a stack of plates having aligned central openings defining a light path through the shutter assembly.

The light path has a longitudinal axis and a plurality of the plates are mounted for rotation around the axis. The assembly includes a shutter blade. A first of the plurality of plates is a rotation guide plate having a guide slot extending from the central opening of the rotation guide plate. The guide slot receives the shutter blade and mounts the shutter blade for translational motion into and out of the central opening of the first plate for selectively blocking a portion of the light path. A second of the plurality of plates is a translation guide plate. A cam and follower combination includes a first camming element on the translation guide plate and a second camming element on the shutter blade engaging the first camming element and moving the shutter blade along the guide slot in response to rotation of the translation guide plate relative to rotation the guide plate.

#### **Brief Description of the Drawing**

[0008] The present invention together with the above and other objects and advantages may best be understood from the following detailed description of the preferred embodiment of the invention illustrated in the drawings, wherein:

[0009] FIG. 1 is a front isometric view of a shutter assembly constructed in accordance with the present invention;

[0010] FIG. 2 is a simplified, diagrammatic view of a luminaire including the shutter assembly of FIG. 1;

[0011] FIG. 3 is a rear isometric view of the shutter assembly with the motor housing cover removed;

[0012] FIG. 4 is an exploded front isometric view of the shutter assembly;

[0013] FIG. 5 is a front isometric view of one shutter subassembly of the shutter assembly including a shutter, shutter guide plate and shutter drive plate;

[0014] FIG. 6 is a rear isometric view of the shutter subassembly of FIG. 5; and

[0015] FIG. 7 is a plan view of a sheet of metal with a pattern for severing from the sheet components of the shutter assembly from the sheet.

#### **Detailed Description of the Preferred Embodiment**

[0016] Having reference now to the drawing, a framing shutter assembly generally designated as 10 is seen in FIG. 1. The shutter assembly 10 is constructed in accordance with the principles of the present invention and includes a shutter section 12 and a drive motor section 14. In accordance with a feature of the invention, the components of the shutter section are made from sheet metal to provide a compact and inexpensive construction that is easily fabricated and assembled, and is sturdy, simple and reliable.

[0017] FIG. 2 is a simplified diagrammatic view of a theatrical luminaire 16 provided with the shutter assembly 10 of the present invention. A luminaire housing 18 contains a light source including a reflector 20. A beam 22 of light is emitted from the reflector 20 and travels in the direction of its longitudinal axis 24 through a lens system including rear and front optical lenses 26 and 28. The light beam 22 is projected through a light exit opening 30 in the housing 18. The shutter assembly 10 is mounted within the housing 18 at a focus point 32 of the reflected light beam 22.

[0018] The framing shutter assembly 10 includes four shutter blades 34, 36, 38 and 40. Each of these blades 34-40 can be moved in a translational direction, radially inward or outward, in order to block a selected portion of the light beam 22. In addition, each of the shutter blades 34-40 can be rotated around the axis 24. The shutter blades 34-40 are preferably identical, although if desired they could differ in shape. The shutter blades 34-40 have straight inner edges 42, although other configurations are possible. The range of translational and rotational motion of the shutter blades 34-40 is such that the shutter

assembly 10 can provide a projected beam of light having any three sided or four sided shape with a wide variation in size.

[0019] The shutter section 12 includes eight aligned, stacked circular plates or disks 44, 46, 48, 50, 52, 54, 56 and 58. The circular plates form a stack 59. Each of the plates 44-58 includes a central aperture 60 providing a light path 62 through the stack 59 for the light beam 22 to travel axially through the shutter assembly 10.

[0020] Four of the circular plates 44, 46, 48 and 50 are rotation guide plates, each supporting one of the shutter blades 34, 36, 38 and 40. The plates 44-50 each have a shutter guide slot 64 extending radially outward from the central aperture 60. The width of the guide slots 64 corresponds to the width of the shutter blades 34-40 and the shutter blades 34-40 are slideably received in the guide slots 64 for sliding translational motion in the radial direction relative to the light path 62.

[0021] The remaining four circular plates 52, 54, 56 and 58 are shutter drive plates. Each of the plates 52-58 has an arcuate cam slot 66. The slots 66 extend in curved, spiral like paths between radially inner and radially outerends. Each shutter blade 34-40 has a cam follower 68 received in one of the cam slots 66. Each cam follower 68 engages only one of the cam slots 66.

[0022] The association between the shutter blades 34-40, the shutter guide plates 44-50 and the shutter drive plates is as follows (see FIG. 4).

[0023] 34 – 44 – 52: shutter blade 34 slides in the guide slot 64 of the shutter guide plate 44, and the cam follower 68 of the shutter blade 34 mates with the cam slot 66 of the shutter drive plate 52.

[0024] 36 – 46 – 54: shutter blade 36 slides in the guide slot 64 of the shutter guide plate 46, and the cam follower 68 of the shutter blade 36 mates with the cam slot 66 of the shutter drive plate 54.

[0025] 38 – 48 – 56: shutter blade 38 slides in the guide slot 64 of the shutter guide plate 48, and the cam follower 68 of the shutter blade 38 mates with the cam slot 66 of the shutter drive plate 56.

[0026] 40 – 50 – 58: shutter blade 40 slides in the guide slot 64 of the shutter guide plate 50, and the cam follower 68 of the shutter blade 40 mates with the cam slot 66 of the shutter drive plate 58.

[0027] The circular plates 44-58 are all mounted for rotation in a nest or cradle structure 70, and each can be rotated independently of the others. The shutter guide plates 44 and 50 include arcuate clearance openings 72 that permit the cam followers 68 of the shutter blades 36 and 38 to extend through the plates 44 and 50 to the cam slots 66 of their associated shutter drive plates 54 and 56. The shutter drive plates 54 and 56 include arcuate clearance openings 74 that permit the cam followers 68 of the shutter blades 34 and 40 to extend through the shutter drive plates 54 and 56 to the cam slots 66 of their associated shutter drive plates 52 and 58.

[0028] To rotate one shutter blade around the light beam axis 24, its associated shutter guide plate and shutter drive plate are rotated simultaneously. To translate one shutter blade radially with respect to the light path 62, its associated shutter guide plate is held stationary while its associated shutter drive plate is rotated. Rotation of the cam slot 66 of the rotating shutter drive plate moves the cam follower 68 of the associated shutter blade, and thus the shutter blade itself, radially in or out.

[0029] One set of associated shutter blade 36, shutter guide plate 46 and shutter drive plate 54 is illustrated in FIGS. 5 and 6. When the shutter guide plate 46 and the shutter drive plate 54 are rotated simultaneously, the shutter blade 36 is rotated in a circular direction around the axis 24 of the light path 62, without any radial motion. When the shutter guide plate 46 is held stationary, and the shutter drive plate 54 is rotated, the rotating cam slot 66 causes the cam follower 68 on the shutter blade 36, together with the shutter blade 36, to move radially inward or radially outward, without rotational motion. If desired,

combinations of radial and rotational shutter motions are also possible, for example by rotating the plates 46 and 54 at different speeds and/or in different directions.

[0030] The circular plates 44-58 are made of a flat planar material, preferably sheet metal. Similarly the shutter blades 34-40 are also made of a flat planar material, preferably sheet metal. Because of the heat of the light beam, stainless steel sheet metal is the preferred material for the shutter blades 34-40. The same stainless steel material can be used for the circular plates 44-58, or alternatively the circular plates 44-58 may be made of a less expensive steel sheet metal. The thickness of the shutter blades 34-40 does not exceed the thickness of the shutter guide plates 44-50 in order that the shutter blades can slide along the guide slots 64. The cam followers 68 can be press fit into openings 75 (FIG. 7) in the shutter blades 34-40. The cam followers 68 may be PEM<sup>®</sup> fasteners from PEM Fastening Systems, 5190 Old Easton Road, Danboro, PA 18916, or studs or buttons that are attached in a similar manner to in the openings 75.

[0031] It is preferred that the thickness of all of the circular plates 44-58 and the thickness of all of the shutter blades 34-40 is the same. This permits all of these parts to be cut or severed from a single sheet of metal. An example of this method is seen FIG. 7 where there is shown a single sheet 76 of metal illustrated with a pattern of sheet metal components for the shutter section 12 of the shutter assembly 10. The illustrated patterned parts can be severed by any desired process such as laser cutting or stamping. The pattern arrangement of FIG. 7 is for illustrative purposes only, and in actual manufacture other approaches can be taken, such as making numerous iterations of single parts in sequence from an elongated roll or web of sheet metal.

[0032] A preferred material for the sheet 76 is twenty-two gauge sheet steel having a thickness of 0.030 inch. If the shutter blades are made from more heat tolerant stainless steel sheet, their thickness can be the same. As seen in FIG. 4, the shutter guide plates 44-50 are located next to one another at the center of the stack 59. This places all of the four shutter blades 34-40 in a closely spaced array along the light

beam axis. The total beam depth of the shutter blades is only 0.120 inch, so that the entire shuttering process is performed at or very close to the light beam focus point 32. This results in a clear, sharply framed, shuttered pattern of the projected light beam 22.

[0033] The stack of four shutter guide plates 44-50 is flanked in front by the shutter drive plates 52 and 54, and at the rear by the shutter drive plates 56 and 58. An advantage of the stack 59 of circular plates 44-58 is that they are self supporting in the axial direction. In addition, the shutter blades are axially captured between adjacent circular plates on both sides so that they are held in the guide slots 64 and yet are free to move radially.

[0034] The nest 70 is formed of a laminar formation 78 of a number of sheet metal rings 80. In the preferred arrangement, there are eight rings 80, equal in number to the eight circular plates 44-58. The ends of the nest 70 are closed by front and rear end plates 82. As seen in FIG. 7, the rings 80 are severed from the same metal sheet 76 as the circular plates 44-58. This has the advantage that the axial depth of the nest 70 is equal to the axial thickness of the stack 59 so that the circular plates 44-58 do not bind or become clamped tightly in the nest 70. Preferably the end plates 82 are also severed from the sheet 76. Another advantage is that sheet thickness tolerance variations from sheet to sheet do not cause clamping or binding of the circular discs 44-58.

[0035] The end plates 82 have central apertures 84 permitting the light beam 22 to travel through the shutter assembly 10. The nest 70 is held together by fasteners 86 (FIGS. 1 and 3) extending through aligned fastener holes 88 in the rings 80 and in the end plates 82. The nest 70 is assembled with the stack 59 in place within circular central holes 102 in the rings 80. Preferably a lubricant such as a dry lubricant is used in the stack 59 to reduce friction. The end plates 82 are thin enough to flex slightly and act as springs biasing the stack 59 together while permitting independent rotation of the circular plates 44-58 and radial motion of the shutter blades 34-40.



[0036] The drive motor section 14 includes eight motors 90 for independently rotating the eight circular plates 44-58. The motors 90 are enclosed in a motor housing 92 including a base 94 and a cover 96. The motors 90 are fastened to the base 94, Nuts 98 (FIG. 4) on the fasteners 86 act as stand-offs to hold the shutter section 12 spaced from and parallel to the motor housing 92. The motor housing 92 and the motors 90 are stationary, and electrical connections can easily be made to operate the motors 90. The base 94 and cover 96 include central openings 100 for passage of the light beam 22.

[0037] Fabrication cost and assembly cost of the shutter section is reduced by the use of common parts, and the number of different parts is minimal. Shutter guide plates 44 and 50 are identical. Shutter guide plates 46 and 48 are identical. Shutter drive plates 52 and 58 are identical. Shutter drive plates 54 and 56 are identical. Shutter blades 34-40 are identical. End plates 82 are identical. The eight sheet metal rings 80 are identical.

[0038] Each of the identical rings 80 includes a circular central opening 102 slightly larger than the diameter of the circular plates 44-58, and a recess 104 adjoining the central opening 102. In the laminar formation 78, the eight rings are oriented by reversing and rotating them so that the recesses are circumferentially spaced apart in a symmetrical pattern around the axis 24. Each of the recesses 104 receives a pinion gear 106. The pinion gears 106 are identical to one another and preferably are cut from the metal sheet 76 so that their thickness is the same as the thickness of the rings 80 and of the circular plates 44-58.

[0039] Each of the circular plates 44-58 is formed with gear teeth 108 for at least part of its periphery. In the stack 59, the gear teeth 108 of each circular plate 44-58 register with one of the recesses 104. Each of the pinion gears 106 meshes with the gear teeth 108 of one of the circular plates 44-58 in order to independently rotate the plates 44-58.

[0040] Each ring 80, in addition to the recess 104, includes seven drive openings 110 in the same symmetrical pattern as the pattern of

recesses 104 in the formation 78. The end plates 82 also have the pattern of drive openings 110. As a result, the drive openings 108 align to form eight drive passages extending axially through the laminar ring formation 78, and each of these passages intersects one of the recesses 104.

[0041] The drive motors 90 are arrayed on the base 94 in the same symmetrical pattern as the recesses 104 and drive openings 110. Each motor 90 includes a drive shaft 112 extending into the formation 78 and drivingly engaging one pinion gear 106. The drive shafts 112 can be D shaped to engage a similar shaped central hole in the pinion gears 106. Operation of any one of the motors 90 results in rotation of the corresponding one of the circular plates 44-58.

[0042] Because the pinion gears 106 are circumferentially offset from one another, each is held in its corresponding recess 104 by the adjacent plates of the stack 59 at both sides. The gears 106 associated with the plates 52 and 58 are also held by the end plates 82. The gears 104 are therefore reliably captured in position without any additional supports or guides.

[0043] While the present invention has been described with reference to the details of the embodiment of the invention shown in the drawing, these details are not intended to limit the scope of the invention as claimed in the appended claims.